

COST EFFECTIVE · NONLINEAR DYNAMIC · PERFORMANCE BASED DESIGN

EXTREME LOADING 5

FOR STRUCTURES

THE PRACTICING ENGINEER'S SOLUTION FOR
ADVANCED NONLINEAR DYNAMIC ANALYSIS

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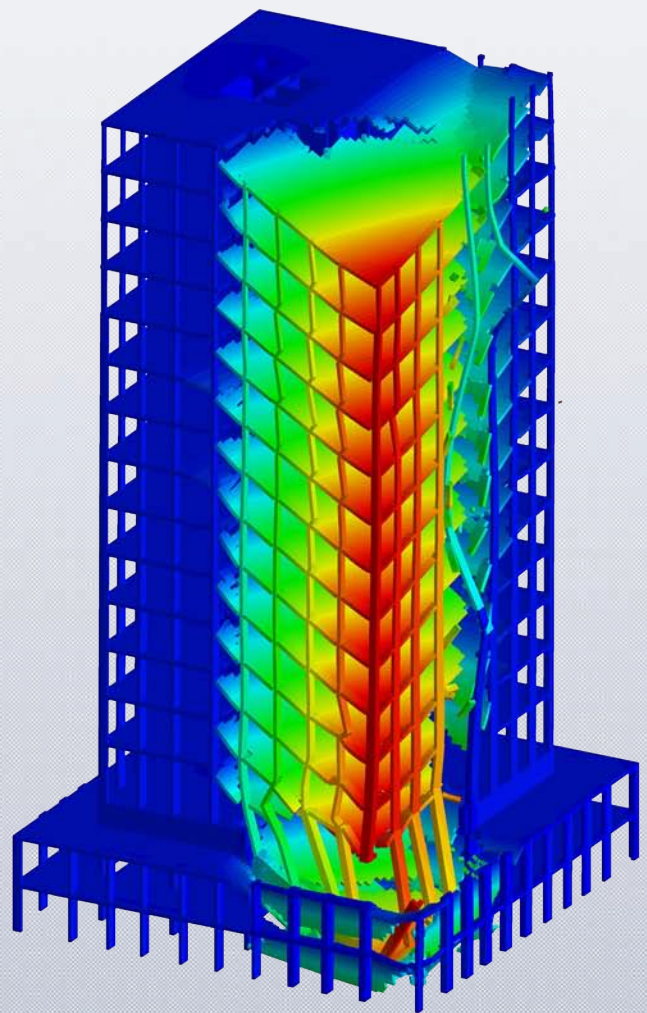
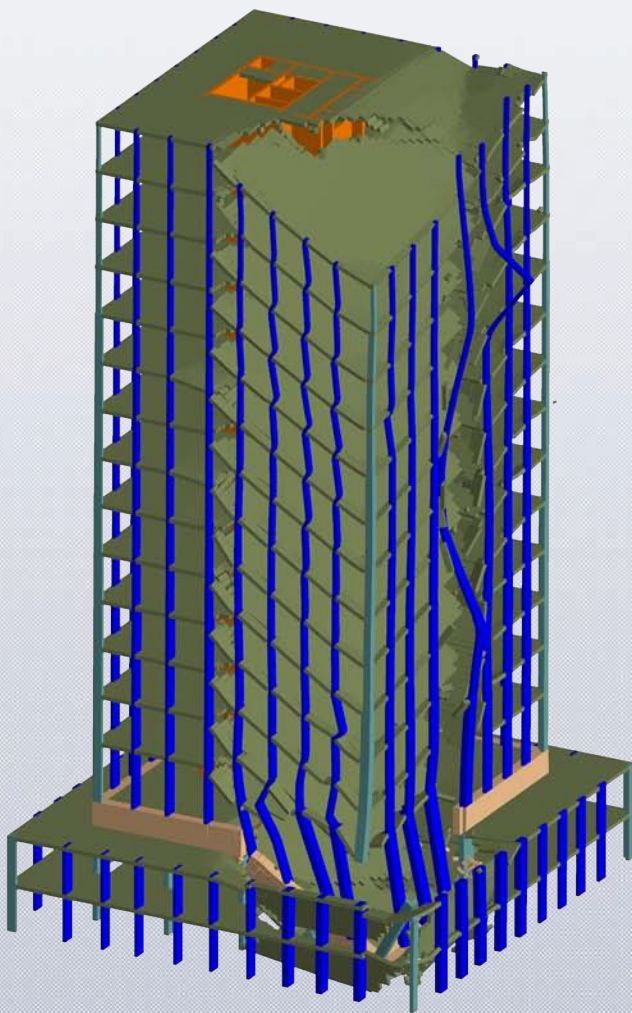
ABOUT EXTREME LOADING FOR STRUCTURES

ASI's Extreme Loading® for Structures (ELS) software is the ideal fully nonlinear structural analysis tool to study the behavior of steel, reinforced concrete, and masonry structures against corrosion, seismic, wind, progressive collapse, and blast. ELS will allow users to easily perform static or dynamic analysis with full nonlinear material and geometric behavior from the elastic to plastic stages including cracking, buckling, post-buckling, P-Delta effects, contact, complete element separation, collision, and effects of falling debris. All are automatically accounted for by the solver.

ELS delivers high-end structural analysis found only in “scientific” software tools in an efficient engineer-friendly package by eliminating the need for transition elements, smearing reinforcement, manual placement of plastic hinges, and other time consuming processes and assumptions associated with FEM software of the past. This results in a more detailed analysis and more accurate results in an economical timeframe.

WHAT'S NEW IN ELS 5?

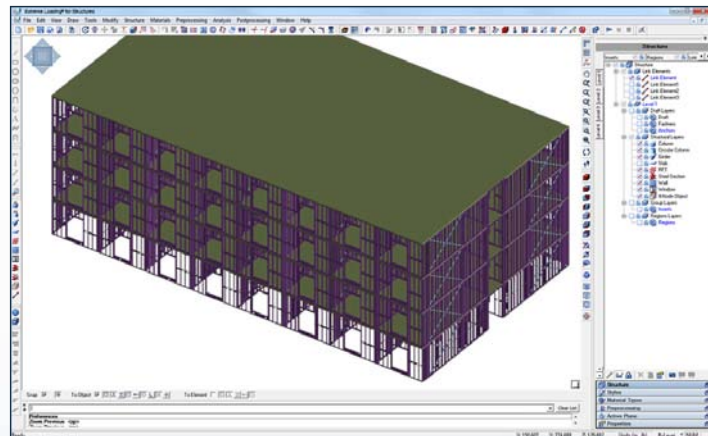
This new version of Extreme Loading® for Structures reinforces the fact that ELS is a practical easy-to-use software program created for practicing engineers who have complex projects with non-traditional load cases. The majority of features provided in version 5 are advanced input methods proposed by software users who wanted additional tools to help them create and solve more complex models. Additional features have been added to provide ease-of-use and versatility for everyday projects.



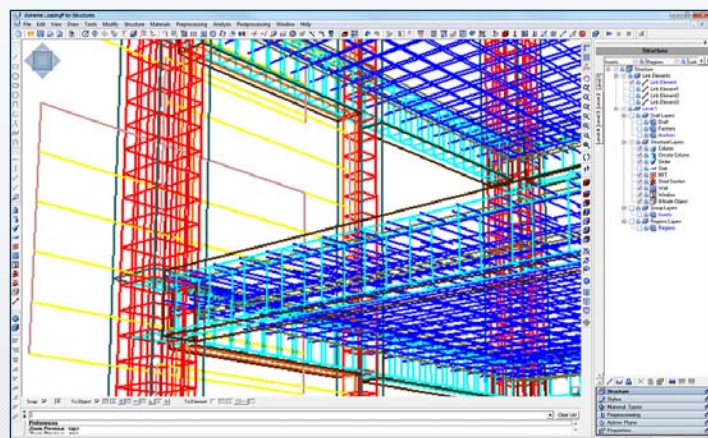
MODELING FEATURES

The Modeler with ELS 5 provides Engineers with an intuitive style-based modeling interface that allows users to quickly and easily create structures in both 2-D and 3-D modes with features such as:

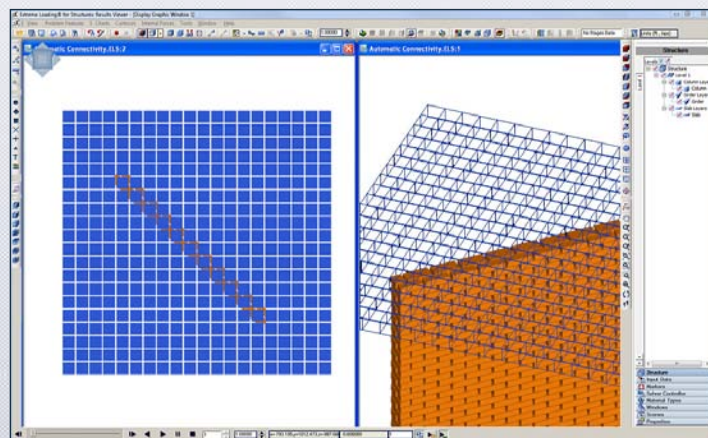
- **Full 3-D Modeling:** build and modify your models in a 3-D environment. All commands are now enabled to work in any view.
- **Style Based Modeling (Building Components):** saves time by allowing the user to use standard building components or edit and create new ones for streamlined modeling.
 - **AISC Steel Section Library:** complete library of metric and imperial steel sections.
 - **Cold-Formed Steel Section Library:** complete library of light steel framing studs and track provided courtesy of The Steel Network, Inc.*
 - **Columns:** create standard and circular girders and customize dimensions, mesh type, material, and embedded reinforcement or steel section style.
 - **Girders:** customize girders by depth, material, and embedded reinforcement or steel section style.
 - **Slabs:** customize slabs by depth, material, and embedded reinforcement or steel section style.
 - **Masonry Walls:** customize masonry walls by thickness, separate brick and mortar materials, with a normal grid or staggered brick pattern.
 - **Multilayer Windows:** create models for single or multi-layer glass sections using newly enhanced window options.
 - **Reinforcement:** model custom reinforcement bars, variably spaced stirrups, and steel sections. Create custom names for reinforcement bars styles custom names and import/export data bases for bar sizes.
 - **8-Node Objects:** create custom 8-node objects.
- **Structure Templates:** create models for trusses, towers, domes, and multi-story buildings with solid or flat slabs using built-in templates.
- **Advanced Modeling Features:**
 - **Convert Draft Objects:** draft objects and convert into girder, masonry wall, RFT, steel section, link members, column & girder structure, steel section component, or polyline.
 - **Enhanced Modeling of Steel Bars:** Automatically convert reinforcement bars inside concrete sections from springs to physical elements for enhanced modeling of steel bars.
 - **Create Hinges:** The ability to create intermediate hinges inside and between columns and girders.
 - **Interface Materials:** Specify custom-created interface materials and specify a custom name using the enhanced Interface Materials dialog.
 - **Extrusion & Revolution:** create objects using the extrusion or surface of revolution commands.
 - **Pre-stressing:** apply pre-stressing in reinforcement bars and link elements.
 - **Cracks & Hole Tool:** model pre-defined existing cracks or holes in structural components.



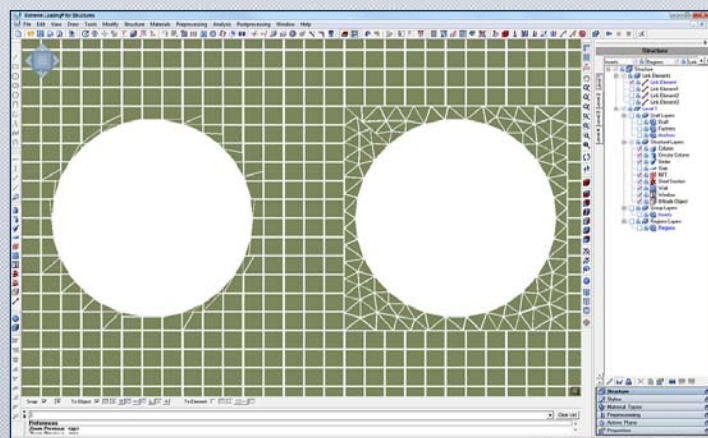
Cold-Formed Steel Structure



Custom Reinforcement

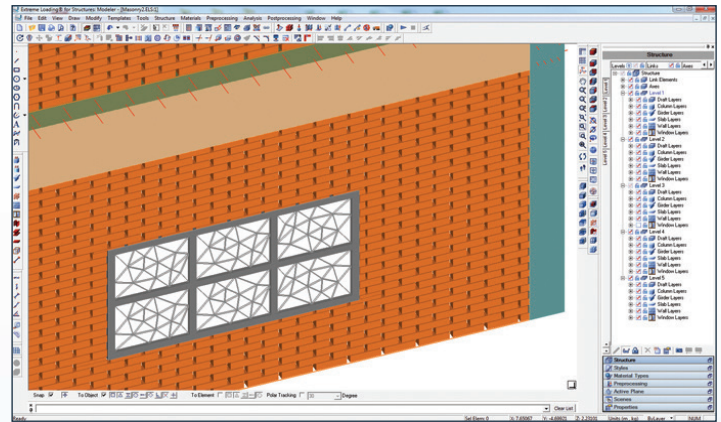


No Re-Meshing Required for Connectivity

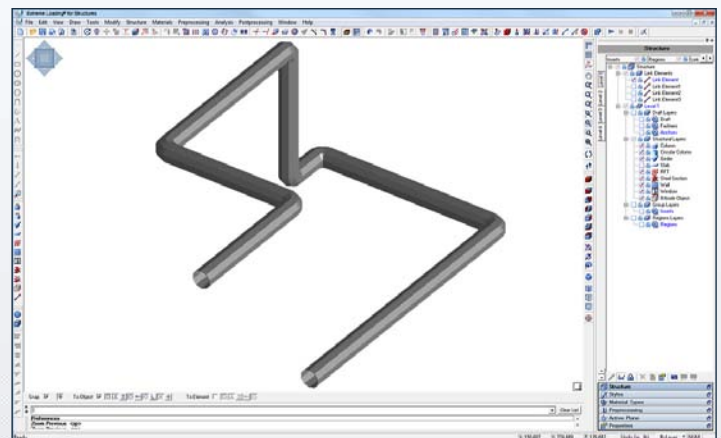


Slab with Hole Before & After Re-meshing

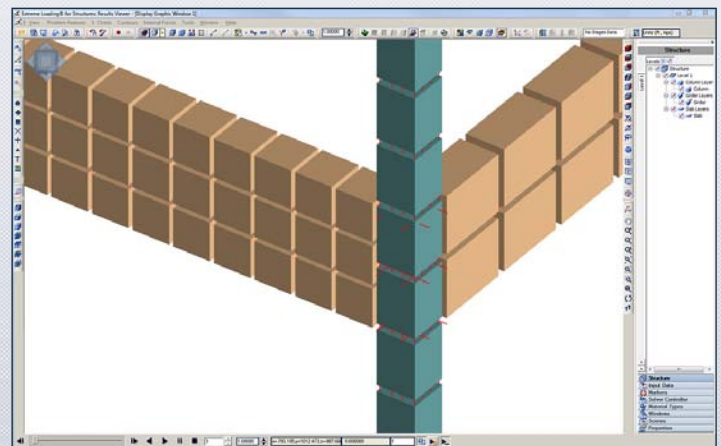
- **Hollow Tubes:** simply create hollow tubes and pipes using drafting lines and selecting mesh properties.
- **Command Line Settings:** define custom command line shortcuts.
- **Modeling Tools & Navigation:**
 - **Active Planes:** Specify active planes to simplify creating 3-D models.
 - **Enhanced Window Options:** Create multiple windows with cascade and tile options or dynamically view your model using snippet view.
 - **Enhanced Show/Hide:** select, show, and hide objects using multiple filtering criteria.
 - **Pick Command:** specify the coordinates of any point you need by simply selecting it using the pick command available in all dialog boxes.
 - **Copy Format:** copy structural objects with assigned loads and boundary conditions.
 - **Multiple Level Arrays:** generate multiple copies of levels.
 - **Snap Options:** helps you build your model quickly and accurately.
 - **Smart Recognition:** helps the user convert lines and shapes either imported or drawn into the modeling window to three-dimensional structural components.
 - **Model Pile Interface:** Ability to model pile interface with surrounding soil without the need to model the ground. This enables the soil-structure interaction to be considered without the need to include huge number of elements for soil.
 - **Import/Export ELS Files:** allow users to import and export all or part of an ELS model from one ELS file to another.
 - **Import Draft Objects:** allows user to import draft objects for reference and conversion into objects.
- **Streamlined Meshing:**
 - **Re-meshing:** re-mesh element selections into square or Voronoi (random triangle) shaped elements to enhance and optimize element size and shape.
 - **Automatic Mesh Adjustment & Element Connectivity:** element connectivity is generated automatically by the program without user-intervention. Remeshing to create transition elements is not required. This saves precious time typically lost due to complex connectivity issues.
 - **Automatic Formation of Plastic Hinges During Static & Dynamic Loading:** the user is not required to make assumptions about which areas are prone to failure as this is determined automatically by the program. This saves time typically lost during trial and error processes.



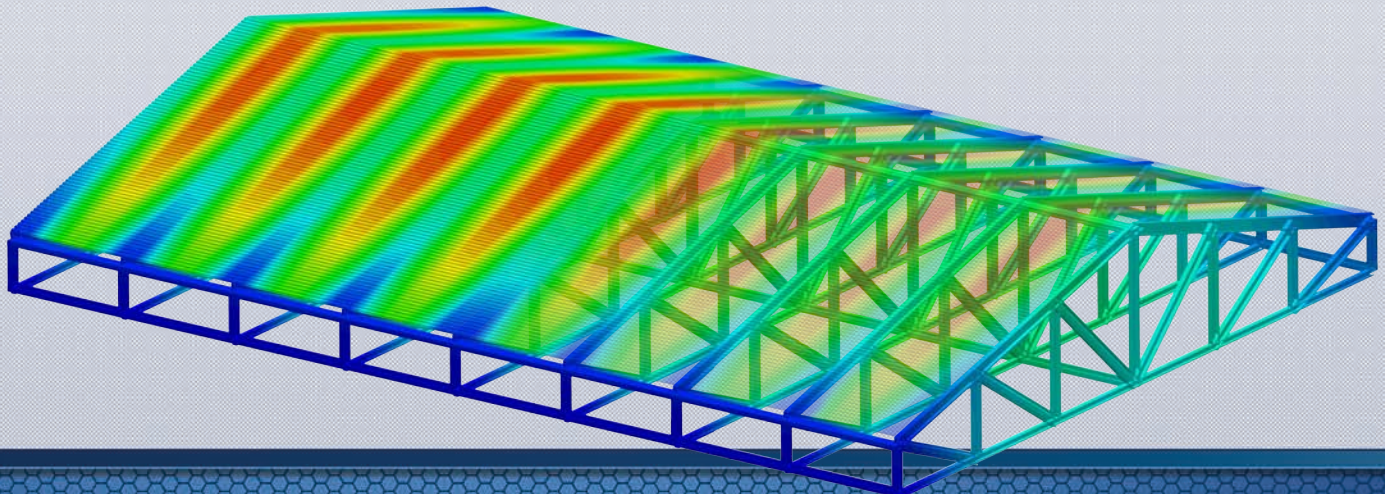
Easily Model Masonry



Pipe Created with Follow-Me Option



Automatic Mesh Adjustment & Element Connectivity



LOADING FEATURES

A wide variety of loading scenarios including multiple successive hazards can be implemented in The Extreme Loading® for Structures 5 utilizing its multi-stage sequential loading:

- **Material Modeling:**

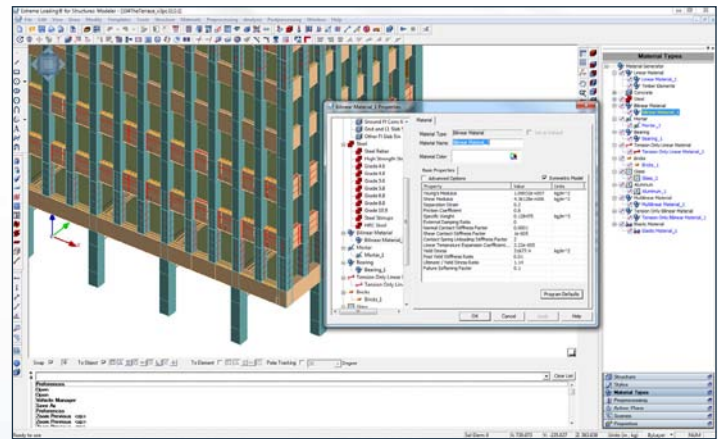
- **Linear Material Models:** for concrete, steel, masonry, mortar, glass, aluminum, bearing, linear elastic, and tension only linear elastic.
- **Nonlinear Materials Models:** for concrete, steel, aluminum, brick, glass, tension only, and elastic, Bilinear, Multilinear, Tension Only Bilinear, Elastic Material, and Tension-Compression.
- **Material Regions:** edit the material of all elements enclosed in a certain region.
- **Spring Filter:** filter springs based on the spring direction. This helps modeling anisotropic materials by assigning different properties for different directions.

- **Loading:**

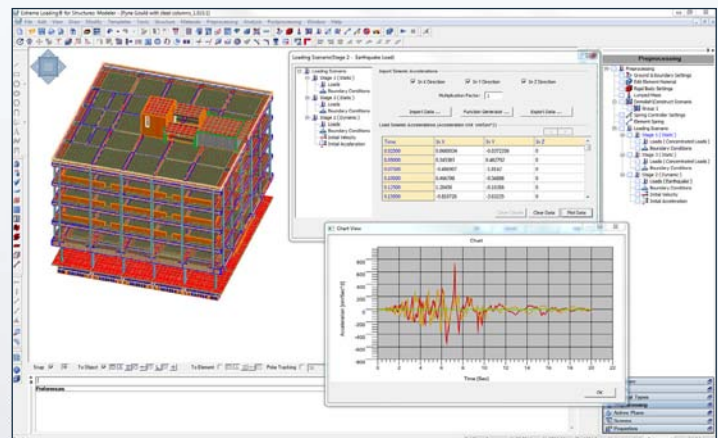
- **Static Loading:** apply concentrated, displacement, hydrostatic pressure, uniform pressure, moving, line, and custom loads.
- **Dynamic Loading:** apply concentrated, displacement, earthquake, blast, uniform pressure, pressure sources, vehicle load, moving, or custom loads.
- **Staged construction and deconstruction:** Activate or remove structural components at different times or stages.
- **Initial velocity and acceleration:** apply initial velocity and/or acceleration to elements or structural component.
- **Corrosion Effects:** consider the effects of corrosion on all types of objects and materials to determine the failure capacity of corroded structures as well as failure capacity after retrofitting.
- **Spring Controller:** gives users control over the properties of springs enclosed in a specified region based on Time or Stage; allowing the user to Change Materials, Add/Remove Springs, Apply Cracks, Apply Temperature Loading, Apply Corrosion, Apply Prestressing.

- **Analysis Settings:**

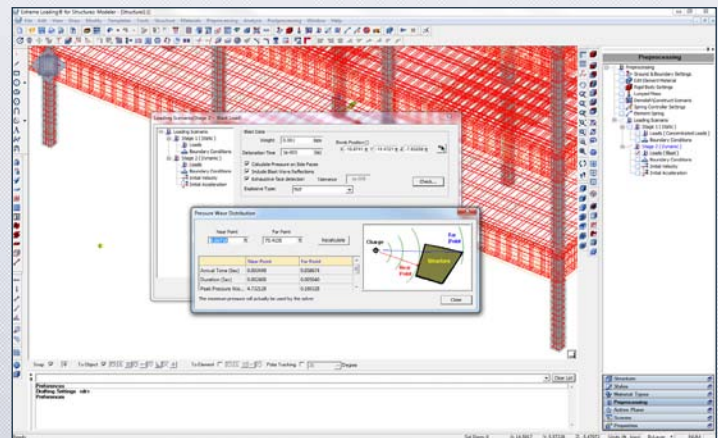
- **Kill Boundaries:** eliminates unwanted debris and decreases simulation time based on “killing” boundary conditions set by the user.
- **Physical Data Conflict Dialogue:** automatically detects conflicts in loads and boundary conditions, allowing the user to remove them.
- **Custom Run:** run the analysis for specific parts of the structure or the whole structure.



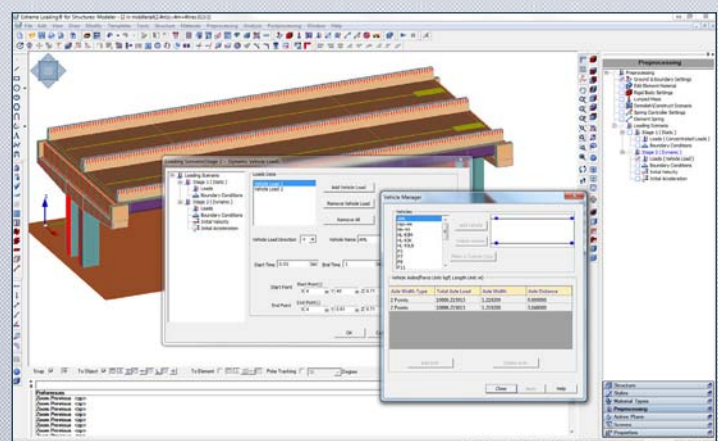
Material Loading



Time-History Earthquake Loading



Blast Loading

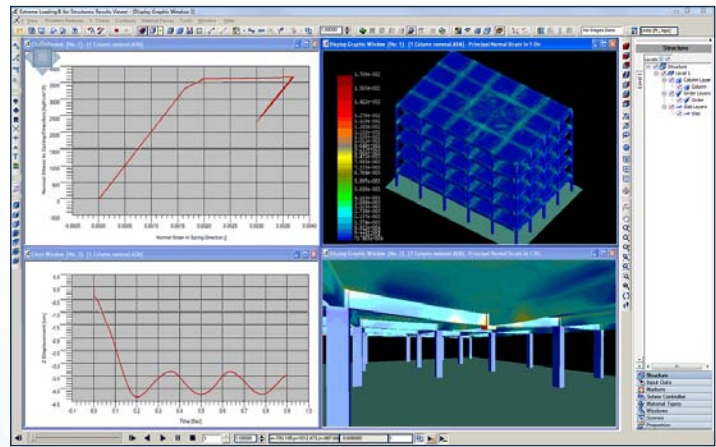
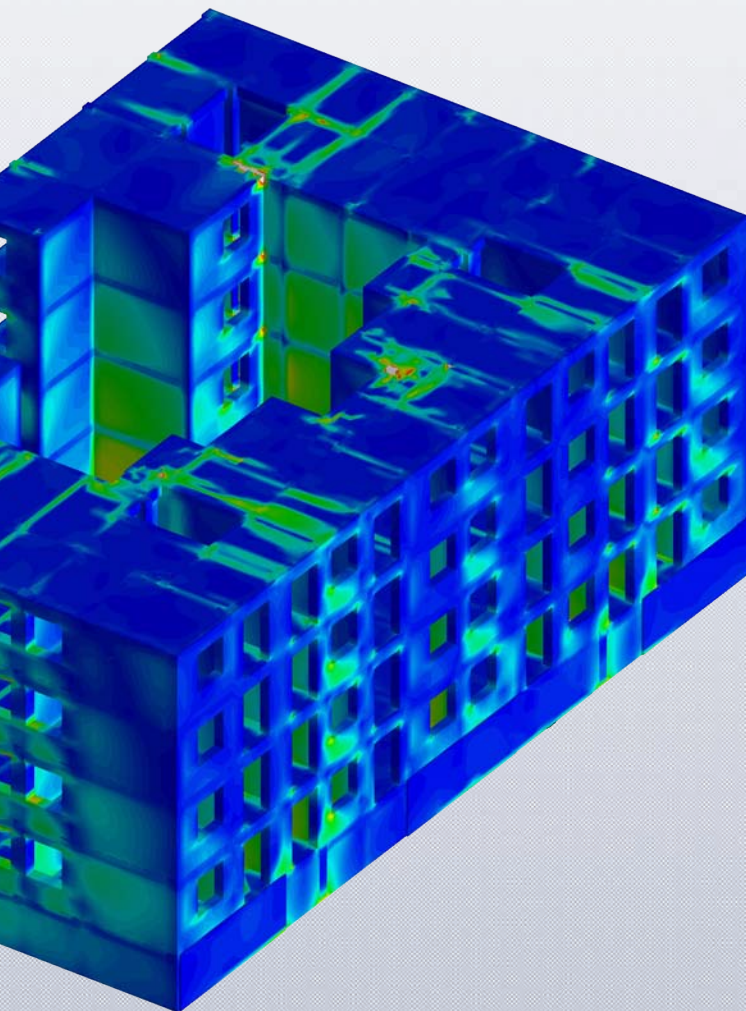


Vehicle Loading

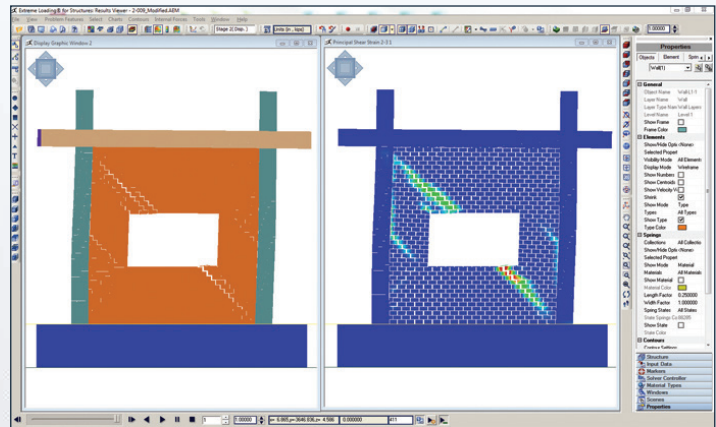
ANALYSIS FEATURES

The Applied Element Method (AEM) based solver in Extreme Loading® for Structures 5 is a derivative of the Finite Element Method (FEM) and the Discrete Element Method (DEM). AEM is capable of performing both linear and nonlinear analysis that follows the behavior of structures through separation, collision and collapse while automatically taking into consideration:

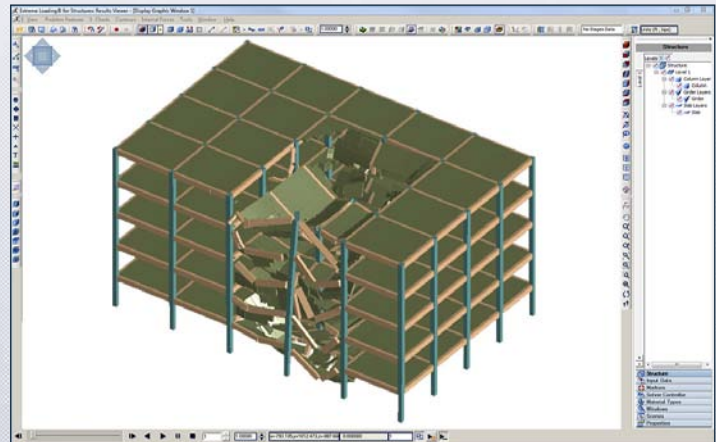
- **Yielding of Reinforcement:** automatically calculates material strain from elastic to plastic deformation.
- **Plastic Hinge Formation:** automatically places plastic hinges.
- **Buckling and Post-Buckling:** automatically calculates elastic and plastic bending under compressive loads.
- **Crack Propagation:** automatically calculates the location and propagation of cracks.
- **Membrane Action & P-Delta Effect (P-Δ):** automatically calculates the dynamic force and displacement caused by Membrane Action and the P-Delta Effect.
- **Separation of Elements:** automatically separates elements based on nonlinear material properties.
- **Collision and Collapse:** automatically calculates the collision and collapse of separated elements.



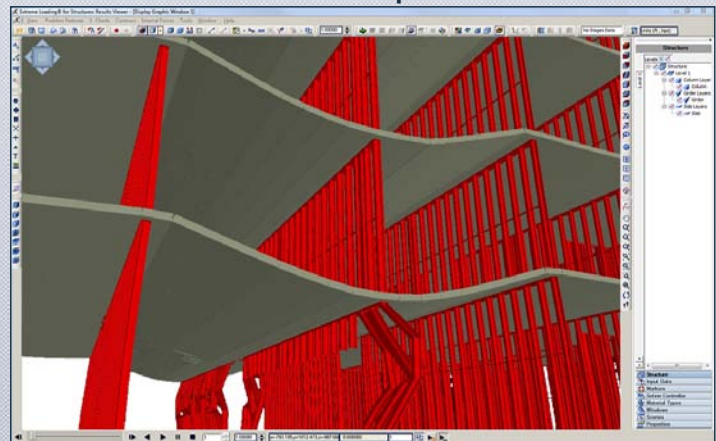
Automatic Plastic Hinge Formation



Automatic Cracking



Automatic Separation

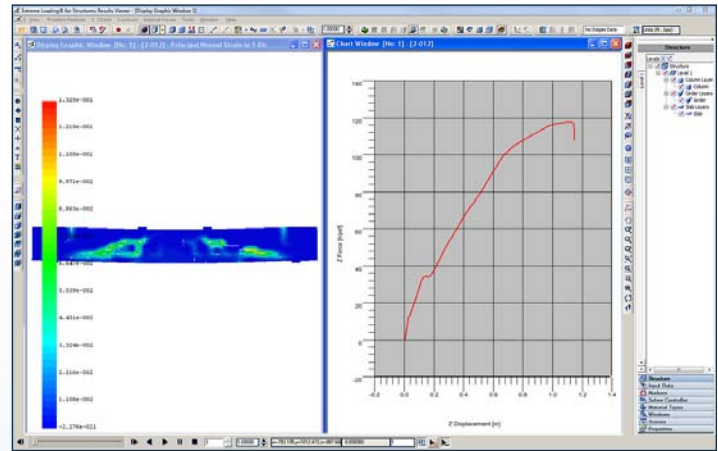


Automatic Membrane Action & P-Δ Effect

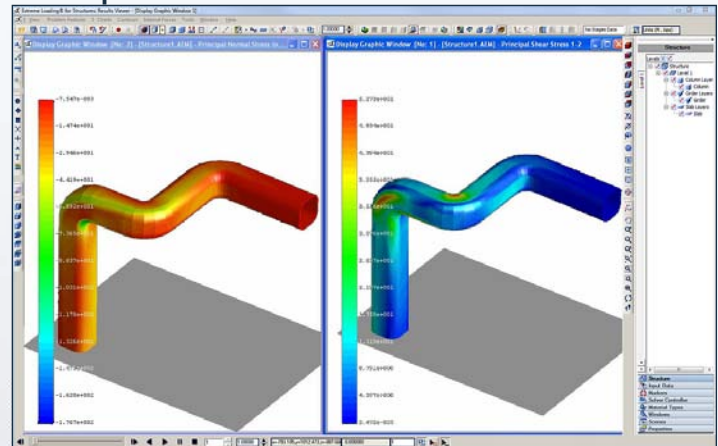
OUTPUT VIEWER FEATURES

The frame by frame Extreme Loading® for Structures Results Viewer allows the user to view, analyze and export presentation materials from the following options:

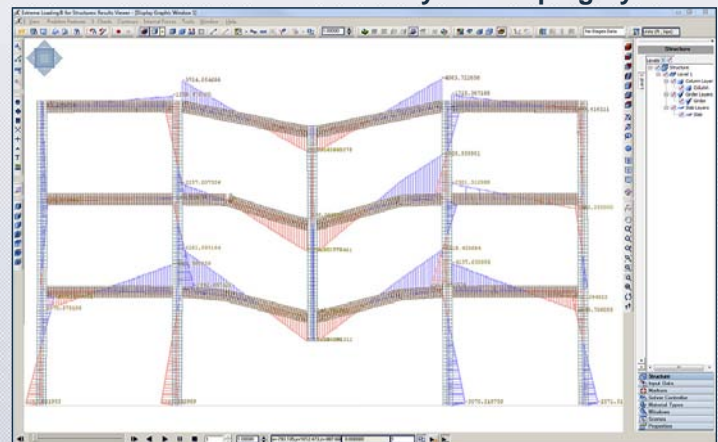
- **Show Status:** Show status of all springs (cracked, yielded, failed in tension or compression, separated, etc.).
- **Create Report:** Create a report on the maximum internal forces in each object separately
- **Filter Elements:** Ability to filter elements or springs based on output values. This enables the user to get elements of specific speed, displacements or acceleration in addition to springs with maximum stress, strain, etc.
- **Problem Features:** gives users several viewing options for interpreting results.
 - Velocity vectors
 - Contact points
 - Blast wave
 - Blast surfaces
 - Crack locations
- **Enhanced Display Controls:** allow users more control over output display and selection of elements, springs, sections, components, or levels.
- **Enhanced Filters:** display objects by material or component type.
- **Eigen modes:** view animated periods and frequencies for all mode shapes of the model.
- **Custom Internal Force Diagrams:** create animated internal force diagrams for components, levels, or the whole structure taking into consideration cracks, rebar, yielding and other phenomena that occur during loading.
 - Bending moment
 - Shear
 - Normal
 - Torsion
- **Contour Diagrams:** create animated stress, strain, and kinematics contour diagrams for components, levels, or the whole structure filtered by the component type or material type.
- **Charts:** allow users more control over all aspects of charts and the ability to animate charts to follow the steps of the analysis.
 - Load
 - Displacement
 - Stress
 - Strain
 - Time
 - Velocity
 - Acceleration
- **Movie Generation:** add text and markers to *.avi and *.bmp.



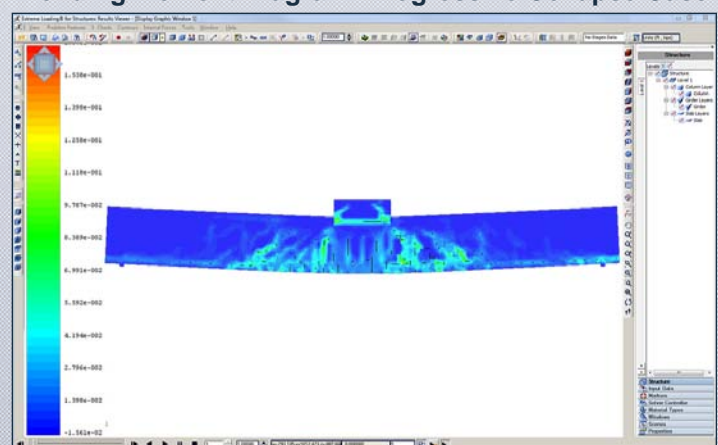
Displacement Chart: Reinforced Concrete Beam



Stress Contours: Seismic Analysis of Piping System



Bending Moment Diagram: Progressive Collapse Case



Stress Contour Diagram: Reinforced Concrete Beam

UPDATED SAMPLES

Samples are problems solved using ELS that discuss static, dynamic, blast, and progressive collapse cases. Most cases document a comparison of analysis performed using ELS with experimental results or analytical solution using other analysis methods or tools. Documentation and an ELS file are available explaining each case. You can use the ELS file to run the sample and view its output.

UPDATED TUTORIALS

Included with ELS are more than 20 video tutorials that take users through all of the steps required to create and analyze various models and analysis cases. These video tutorials are updated and added to on a regular basis and as new features are added.

ASI PORTAL

From the new ASI User Portal, Licensed ELS Users have 25-7 access to Software Updates, Tutorials, Quick Start Guide, Modeler Manual, Blast Manual, Viewer Manual, Theoretical Manual, Technical Reference Manual and the ability to upgrade or renew their license.

ELS CERTIFIED TRAINING

In addition to the startup materials that come with each license of Extreme Loading® for Structures Software (ELS), users will benefit from completing the Extreme Loading® for Structures Certification program. Training modules include:

- Structural Vulnerability Assessment
- Blast Analysis
- Progressive Collapse Analysis
- Seismic Analysis
- Forensic Engineering
- Performance Based Design

For more information on ELS Certified Training visit www.extremeloading.com/customer-services-support/els-certified-training

PROJECT SUPPORT

ASI offers ELS users various levels of project support. From modeling assistance, to peer review, to custom materials and loading, to remote simulation, to full project consultation services, ASI is here for you! For more information visit <http://www.extremeloading.com/customer-services-support/project-support>

ADDITIONAL INFORMATION OR PURCHASE

For more information or a quote for Extreme Loading® for Structures visit www.extremeloading.com or call us at 1-919-645-5090.

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SYSTEM REQUIREMENTS

Minimum:

- Operating System: Windows 7, 8, 8.1, & 10 (All 64 bit only)
- Hard Disk: 1 GB for Installation
- Memory: 1 GB RAM
- Processor: 64bit-Processor
- Graphics Card: With OpenGL Support

Recommended:

- Operating System: Windows 7, 8, 8.1, & 10 (All 64 bit only)
- Hard Disk: 1 GB for Installation
- Memory: 32 GB RAM
- Processor: 64bit-Processor with Multiple Cores
- Graphics Card: With OpenGL Support , Memory 2 GB or Higher





APPLIED SCIENCE INTERNATIONAL SUCCESS STORY

BOODARIE REACTOR DEMOLITION

Western Australia, 2012

The Largest Demolition Project in the Southern Hemisphere

The HBI Boodarie Iron Site is one of the largest, most complex demolition projects undertaken by any demolition company in the southern hemisphere. Located in one of the most remote and desolate parts of North Western Australia, this site was built to withstand cyclones, and earthquakes.



With structures that tower a hundred meters high, and comprising of over twenty five thousand tons of steel, the Liberty Industrial demolition team was charged with bringing this Colossus crashing down. The stakes were extraordinarily high. If the demolition does not go as planned, half-collapsed unstable structures could be left standing... not only exponentially increasing costs, but also exposing the crew to highly dangerous conditions.

When even the smallest miscalculation could place the entire project in jeopardy, the Liberty Industrial team turned to Applied Science International for state-of-the-art engineered analysis that can identify potential problems before they arise. Extreme Loading® for Structures software can simulate local failure to global response, and everything

in between, allowing the Liberty Industrial team to effectively watch the collapse of the structure before even setting foot on the demolition site, and before the first cuts are made.

The HBI Boodarie closure plan included the induced collapse of several structures using strategic weakening cuts and a cable pulled by an excavator, as well as one impressive explosive demolition that split the largest structure on the site in half. Extreme Loading was able to analyze both scenario types and provide visuals and recommendations for the crew on the ground.

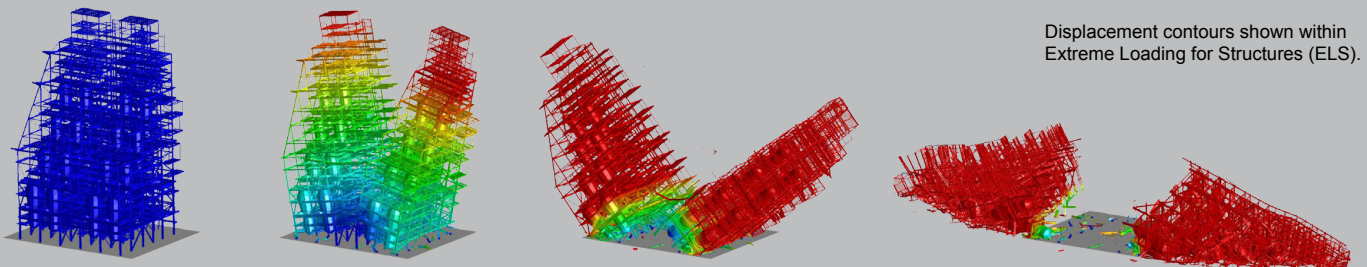
With thousands of weakening cuts made, and no second chances, it took only 8 seconds for the equivalent weight of 10,000 cars to be brought crashing down to earth. The fall was a complete success because of the teamwork exhibited by the demolition crew and the technological advancements provided by ASI's engineering team. And as part of Liberty Industrial's on-going commitment to efficient waste management and environmental concerns, all scrap steel was processed in accordance with strict export guidelines. After twelve months, and over 100,000 man-hours, the HBI Boodarie plant is no more.

HBI Reactor 3D model created with Extreme Loading for Structures.



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Displacement contours shown within Extreme Loading for Structures (ELS).

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APPLIED SCIENCE INTERNATIONAL SUCCESS STORY

PREHEATER STACK DEMOLITION

Hismelt Kwinana Plant, 2013

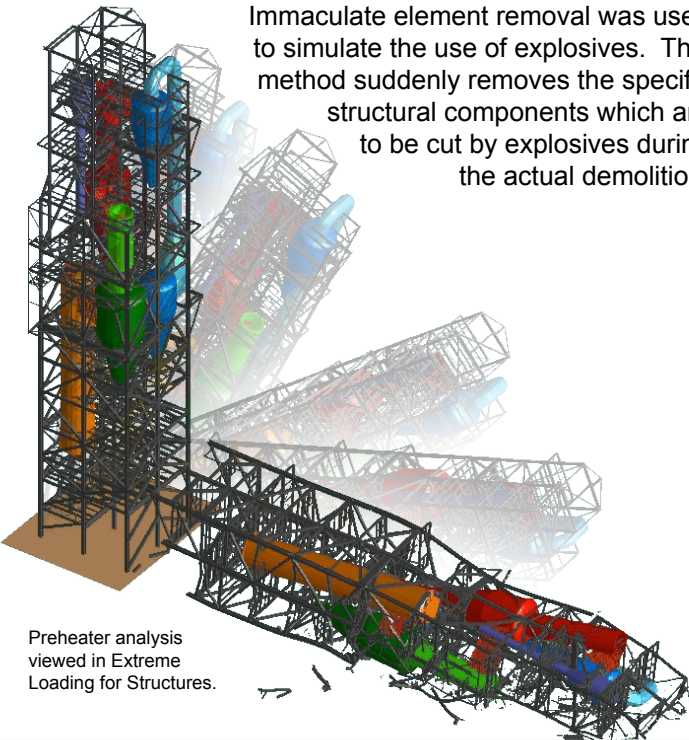
Demolition, Wind Load, and Ground Vibration Analysis In One Software Program

Liberty Industrial tasked the engineers at Applied Science International (ASI) to investigate the demolition of the preheater stack structure at the Hismelt Kwinana Plant in Western Australia. The demolition scenario proposed by Liberty Industrial involved initial weakening followed by explosive demolition.



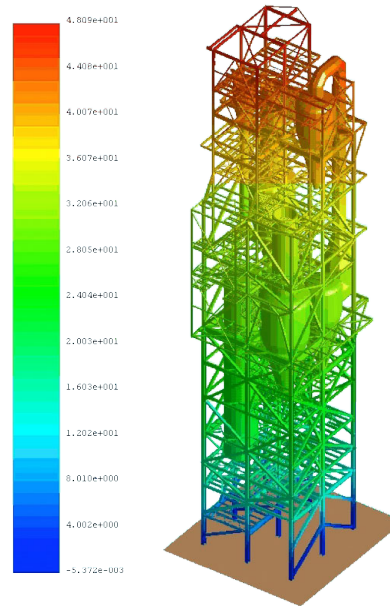
The nonlinear dynamic analysis performed by ASI in Extreme Loading® for Structures considered the weight of the stack's multiple internal structures in addition to a wind load of 104 kilometers per hour. Two separate wind loading analysis were carried out to study the possibility of failure due to wind.

Immaculate element removal was used to simulate the use of explosives. This method suddenly removes the specific structural components which are to be cut by explosives during the actual demolition.



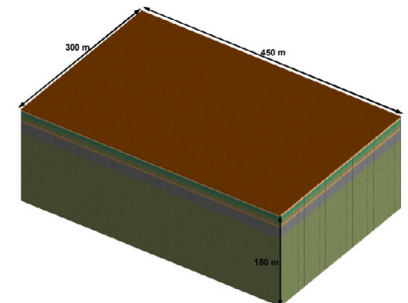
Preheater analysis viewed in Extreme Loading for Structures.

Additionally, a 450m by 300m linear-static soil model was created in ELS with a depth of 160m. These dimensions were chosen based on a preliminary analysis and the model was used to determine the potential impact force on surrounding structures that would result from the preheater collapse during demolition. The figure below shows the impact load of the preheater over time.



Wind analysis of the preheater stack viewed in Extreme Loading® for Structures.

The results of the engineered analysis verified that the proposed demolition plan was suitable and that the members removed by explosives would be sufficient to cause the structure to fail in the desired direction. Furthermore, the wind loading study showed that the proposed weakening scenario was safe up to the anticipated 104kph wind load. Lastly, the maximum peak particle velocity for the soils at the surrounding structures was found to be 52 mm/sec, well within acceptable tolerances.



Soil model created in ELS.

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